ORIGINAL RESEARCH

SIMULATOR SICKNESS IN AIRFOX® DISORIENTATION SIMULATOR

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INTRODUCTION

A simulator is defined as a machine with a similar set of controls designed to provide a realistic imitation of the operation of a vehicle, aircraft, or other systems. These simulators provide safe and controlled environments to train the users on vehicle and device operation, to evaluate the safety of devices and controls and to conduct research on driving and driving behaviors [1]. The use of flight simulator for training aircrew (both military and commercial) has increased since World War II. Aircrew training involves use of sophisticated ground-based flight simulators [2]. In any training incident / accident, the loss of a pilot and an aircraft costs in terms of money and manpower; and in turn, decrease overall operational capability [3]. The simulators enable experience of a broad range of flight conditions and emergency procedures without jeopardizing flight safety. However, as the use of flight simulators has consistently increased over the years, a phenomenon known as simulator sickness (a subset of a larger entity of motion sickness syndrome) upon simulator exposure (SE) came into light. It is also known as visually-induced motion sickness (MS) [4]. This Simulator Sickness (SS) has been largely considered to be a persistent limiting factor in continuing flying training [5]. Simulator sickness (SS) is classically characterized by nausea, dizziness, postural instability, fatigue and general malaise [5, 6]. On cessation of SE, few symptoms may persist up to several hours; these symptoms are called after-effects. These after-effects may have adverse impact on postsimulator training activities [5].

These symptoms can be measured both subjectively (using questionnaires) and objectively (using biomedical instrumentation) for research purposes. SS appears to be most pronounced in high performance aircraft and helicopter simulators [5]. AirFox® DISO, a disorientation simulator is widely used in Indian Air Force to train aircrew of all streams (fighters, transport and helicopters) on spatial disorientation. No data is available in respect of the incidence of simulator sickness on AirFox® DISO and also on incidence of simulator sickness in Indian aircrew.

ABSTRACT

Use of flight simulators has consistently increased over the years, a phenomenon known as simulator sickness upon simulator exposure (SE) has been of concern in aircrew. This Simulator Sickness (SS) has been largely considered to be a persistent limiting factor in continuing flying training. It is classically characterized by nausea, dizziness, postural instability, fatigue and general malaise. On cessation of SE, few symptoms may persist up to several hours and these may have an adverse impact on post-simulator training activities. AirFox® DISO, is widely used in Indian Air Force (IAF) to train aircrew on spatial disorientation. The paper presents a study carried out in IAF on the aircrew reporting to IAM, IAF Bangalore for training. The results are presented based on the Simulator Sickness Questionnaire (SSQ) administered to the aircrew.

AIM

The study aimed to determine the incidence of simulator sickness in Indian aircrew after a simulator exposure using the AirFox® DISO using a Simulator Sickness Questionnaire (SSQ).

MATERIALS AND METHODOLOGY

The study was carried out on the AirFox® Disorientation (DISO) installed in the Department of Acceleration Physiology & Spatial Orientation at Institute of Aerospace Medicine (IAM), Indian Air Force (IAF), Bangalore.

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Simulator Capabilities

It is an advanced spatial disorientation training simulator with six degrees of freedom motion system (Roll, Pitch, Yaw, Heave, Surge, Sway) along with continuously rotating yaw system.

Demographics

60 healthy Indian aircrew aged between 21 to 50 years participated in the study. The protocol for the study was approved from the Institute Ethics Committee. A written consent was taken from the subjects after they were fully briefed regarding the protocol and the risks involved. A thorough history was taken to exclude any unsuitability for the study. All the subjects were examined clinically before the experiment.

The subjects had the option of withdrawing from the study at any point of time during the study.

Inclusion Criteria

The inclusion criteria was healthy male aircrew of all the streams (viz. fighter, transport and helicopter) between age bracket of 21 years to 50 years,

Exclusion Criteria

The exclusion criteria included female subjects, non-pilots, civil pilots or aircrew with any illness or on any medication.

Protocol

The subjects were briefed about the protocol of simulator profile and instructed to fly the same Free Flight profile for a period of 45 minutes. The profile comprised of general handling turns and maneuvers like loops and rolls. The free flight profile of 45 minutes was developed with the help of a Qualified Flight Instructor. After proper briefing, the participant was strapped to the seat (inside the cockpit). The radio-communication was checked. After starting the AirFox® DISO, the Free Flight profile was selected for simulation.

Simulator Sickness Estimation

Simulator Sickness Questionnaire (SSQ) is the gold standard for measuring SS [2, 6, 7, 8, 9, 11]. This questionnaire consists of 16 symptoms associated with SS. It was administered as soon as subject came out of the generic cockpit. The subjects were instructed to "Please indicate the severity of symptoms that apply to them "right now" by circling the appropriate word". SSQ provides four subscales viz. Nausea (N), Oculomotor (O) & Disorientation (D) and Total Severity (TS) scores. Total Severity is a convenient summary of impact of simulator exposure on different target systems within humans. Only SSQ-TS was used for statistical analysis because it is computed by adding the sums of symptomrating for nausea, oculomotor and disorientation subscales and thus is the single best index of overall severity [11].

RESULTS

A total of 60 subjects were studied for the after-effects of SE in terms of simulator sickness. It was measured and scored to calculate the incidence of SS as per laid down methodology. The incidence of SS was calculated by listing the percentage of participants who reported at least one symptom following simulator exposure. Incidence of SS in present study was 70%. 42 out of 60 subjects reported at least one symptom.

Main Symptoms Reported By Subjects

Symptom Reported	% Reported
Fullness of head	60%
Dizziness while eyes were closed	50%
Eye strain	45%
General discomfort	25%

Symptomatic subjects (n=42) were distributed in two groups viz. group A and B on the basis of age. 34 out of 48 subjects from group A had SS. The mean age of subjects in group A and B was 25.75±7.42 years and 32.17±4.62 years respectively. There was significant difference in age between group A and B.

DISCUSSION

The present study was undertaken with the aim to study the incidence of simulator sickness in Indian aircrew using AirFox® Disorientation Simulator. Additionally, it studied the role of age, flying experience and history of motion sickness or simulator sickness in causation of SS.

The data on incidence and susceptibility of IAF aircrew to simulator sickness is limited. Thus, the aims and objectives were decided with a view to study various factors pertaining to causation of SS in Indian aircrew so that the outcome of simulator training can be improved.

In the present study, the incidence of SS (using SSQ) was found to be 70%. The older experienced subjects were found to have more SS than the younger subjects. None of the subjects reported any history of MS / SS. The result of the present study is similar to studies done by Braithwaite el al (1990) Kolasinski (1995), Kennedy & Fowlkes (1992) and Johnson (2007) [2, 13, 14, 15].

As per the Simulator Sickness Questionnaire (SSQ), in the present study, the commonly reported symptoms were fullness of head (60%), dizziness with eyes closed (50%), eye strain (45%) and general discomfort (25%). Johnson (2005) reported that eyestrain (37%) and fatigue (27%) were the common symptoms whereas Braithwaite and Braithwaite reported that commonly reported symptoms were disorientation (24%) and difficult focusing (24%) [7, 15]. Kennedy et al found that fatigue (43%), sweating (30%) and eyestrain were the common symptoms reported by subjects [13]. The responses given by subjects [13]. The responses given by subjects in the present study are similar to those in the earlier studies mentioned above.

Immediately post-simulator exposure, the mean SSQ-TS scores in present study was reported as 16.08. This indicates a concern for post-simulation activities taken soon after exiting simulator, as reported by Kennedy et al [14]. It implies that the AirFox® Disorientation simulator produced symptoms of SS which raise concern for post-simulator exposure activities.

Using SSQ-TS scores, the incidence of SS in the present study was found to be 70%. In the review by McCauley (1984), incidence was reported to range from 10-80% [10]. Braithwaite and Braithwaite reported an incidence of 60% during simulation in Lynx helicopter simulator [15]. Kennedy & Fowlkes found that incidence ranged from 12-60% [13]. Pausch et el (1992), in their review, reported that it could range from 0- 90% [4]. The result of the present study is similar to the findings by Pausch et al and Kennedy & Fowlkes.

In the present study, the following factors were found to increase the risk of SS.

a. Dynamic Simulator. AirFox® DISO is a dynamic motionbased simulator with 6-degrees of freedom. McCauley and Miller et al independently reported that the simulators with moving-base system like high performance aircraft and helicopter simulators produce more SS [8, 10]. In her review, Kolasinski found that moving-base simulators increase ataxia [2]. Jones (2011) commented that this could be because of the fact that non-correspondence of visual and motion cues may induce more visuo-vestibular conflicts [1]. Thus the motion-based simulator could be a contributing factor in increasing SS in the present study.

b. Duration of Simulator Exposure. In the present study, all the subjects were given a single simulator flying experience for a continuous period of 45 minutes. Kennedy et al (2000) reported that MS accumulates with time which suggests that the symptoms will increase as the duration increases. They also reported that the duration of the simulation positively correlates with sickness levels i.e. SS increases within the duration of a single simulation session [12]. Pausch et al found that this is due to the fact that increase in duration of simulator session increases the visuo-vestibular mismatch [4]. The duration of simulation in the present study was 45 minutes whereas the symptoms and signs of SS can appear within 10 minutes of simulation. The exposure duration is considered to be one of the most effective ways to control the severity of sickness because of its cumulative effect as reported by Johnson [7]. In the present study the duration of simulator exposure (i.e. 45 minutes) might have been the reason for occurrence of SS.

c. Simulator flying experience. All the subject flew the same profile (which presented a novel visual-vestibular conflict) for a duration of 45 minutes. The profile comprised of general handling sortie in a fixed-wing aircraft. There were no freeze / reset commands and no flying backwards scenarios which are conducive to SS. Johnson in his review, found that freeze/reset function was implicated as causal in producing SS [7]. The scenes presented during simulation were simple as a scene that is too complex can increase sickness especially emetic responses as reported by Kennedy and Fowlkes [13]. The subjects were in full control of simulator flying. Miller and Goodson, in their report on MS in a helicopter, revealed that an aircrew in pilot rather than co-pilot position is particularly susceptible because he/she would have the greatest potential for discrepancies to develop between expectation of the control / response characteristics of the real aircraft and those of the simulator [3]. In the present study as the subjects were actively flying during simulator exposure, they were more prone to SS.

d. Ethnicity. Individuals of Asian origin are more susceptible to MS than Caucasian so the racial factor might have increased the risk of SS. It is possibly due to environmental factors or genetic differences in central catecholamine release [2]. In the present study, the incidence of 70% indicates that the Asians were found to have more SS than Caucasians.

In addition, there are some other factors which might have reduced the risk of Simulator sickness. These factors include the following:-

a. Field of view. AirFox® Diso simulator has a comparatively smaller FOV (horizontal=45° and vertical=30°). A large FOV (of >60° in dimension) has been found to be conducive to SS because it allows a large flow of optical information and can magnify the effects of any distortions in the visual displays as reported by McCauley (1984), Pausch et al (1992), [4, 10]. According to Kennedy & Fowlkes a wide FOV have been associated with increased susceptibility to SS [13]. Kolasinski in her review on SS in virtual environment showed that a wide FOV makes individuals prone to SS [2]. In the present study, a smaller FOV appears to decrease susceptibility to SS.

b. Simulation of fixed-wing aircraft. The profile comprised of general handling sortie in a fixed-wing aircraft. According to review by Jones, the incidence appears to be most pronounced in high performance aircraft and helicopter simulators [1]. In the present study, the simulation of flying experience in a fixed-wing aircraft might have reduced the susceptibility to SS.

c. Individual factors. The several individual factors like age, health status, flying experience, avoidance of medication and alcohol were considered in inclusion and exclusion criteria to minimize SS. Kolasinski found that the illness, medication, alcohol increase the propensity to become simulator sick [2]. In his review on simulator sickness research, Johnson mentioned that ill-health, older age, more flying experience, medication and alcohol intake all predispose to occurrence of SS [7]. In the present study, the subjects were healthy and avoided alcohol 24 hrs prior to the study thereby reducing the risk of SS.

d. Prior history of MS/SS. In behavioral sciences, the past behavior is the best predictor of future behavior. It follows that people who have a history of prior episodes of MS or SS are more likely to experience SS in future simulator-based training [7]. Braithwaite and Braithwaite (1990) reported that among their sample of helicopter pilots training in a Lynx simulator, there was a significant positive correlation between self-reported prior history of motion sickness and SS. That is, those with a history of MS experienced more SS in the helicopter simulator [15]. Gower and Fowlkes reported a significant positive correlation between past history of MS as reported on the MHQ and reported SS while training in the Cobra Flight Weapon Simulator [7]. However, in the present study, the active role of this factor is eliminated as none of the subjects reported any history of MS or SS (prior to the exposure).

CONCLUSION

With a view to study the incidence of simulator sickness in Indian aircrew using AirFox® 60 healthy male volunteers were given a single simulator exposure in the form of a Free Flight profile (for a duration of 45 min) in the AirFox® DISO simulator. The effects of simulator flying experience (given in AirFox® DISO simulator) caused Simulator Sickness and the same was assessed using SSQ, a gold standard for the same. The SSQ was administered immediately post-SE and SSQ-TS scores were compiled and scored. The incidence of SS was found to be 70%. The commonly reported symptoms were fullness of head, dizziness with eyes closed, eye strain and general discomfort. The study showed that aircrew in AirFox® Disorientation simulator did report symptoms pertaining to SS and these symptoms were scored to calculate the incidence of SS (=70%) which was found to be high. Thus, this study concludes that the simulator exposure in this simulator produce SS.

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